

Refer to: McCrady-Kahn VL, Kahn AM: Lightning burns. *West J Med* 134:215-219, Mar 1981

## Lightning Burns

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OUR ENVIRONMENT PRESENTS numerous sources for burn injuries from electricity, chemicals and flammable synthetic materials. Often overlooked are the natural rather than man-made environmental factors such as sun, lightning, lava from erupting volcanoes, and steam and hot water from erupting geysers that can likewise cause burns. The average annual number of deaths in the United States due to lightning accidents is estimated to be between 100 and 600, and lightning causes more deaths directly than does any other weather phenomenon. Surprisingly, about two thirds of those persons involved in lightning accidents make a complete recovery. Most survivors are not directly struck by the lightning but receive electrical shock as a result of being in the close vicinity of a lightning strike.<sup>1</sup> Few physicians see cases of lightning injury, consequently most physicians are inexperienced in the management of these injuries. The purpose of this paper is to present a case of lightning injury and a discussion of the management of such injuries.

### Report of a Case

A 10-year-old boy was playing beneath a tree during a rain storm. A bolt of lightning directly struck the tree and the scatter struck the child. Rescuers, almost immediately at the scene, found him to be unconscious, apneic and with his jacket on fire. The fire was extinguished, immediate mouth to mouth respiratory resuscitation was begun and the boy was transported by the paramedic rescue squad to a nearby hospital's emergency room. In the emergency room he vomited then aspirated and was intubated. Following intubation, pulmonary lavage was carried out and administration of corticosteroids was begun. Sei-

zures were observed but not initially treated with anticonvulsant medications. Intravenous fluid therapy was begun and the boy was then transferred by helicopter to our burn center.

Upon arrival at the burn center he was found to be responsive to pain and moving his extremities. Burn wounds were present over 31 percent of his body surface. Typical deep partial and full thickness flame burns were present on both hands, anterior chest, neck, and the right side of the face and scalp. Completely different appearing burns were present on both thighs and the right leg. Over these areas, the burn wounds had a spidery or flower-like appearance (Figure 1).

Immediate and serial radiographic, electrocardiographic and laboratory studies were done. The first x-ray film of the chest showed mediastinal emphysema and this steadily expanded to include the subcutaneous tissue and the subdiaphragmatic intraperitoneal space by the third day. Pulmonary parenchymal infiltrates were present and gradually resolved.

The initial electrocardiogram showed ST segment elevation in leads V<sub>2</sub> and V<sub>3</sub> and this resolved within a few hours. Daily studies of creatine phosphokinase with isoenzymes were done beginning on the day of admission and the cardiac isoenzyme (MB) was never elevated.

Over the course of 12 days the patient's neurological state rapidly improved. Intermittently early seizures were controlled with anticonvulsants. X-ray studies of the skull and computed tomography of the head showed no abnormalities. Electroencephalograms on two occasions were abnormal with an excess of symmetrical slowing. An echoencephalogram was normal.

Upper gastrointestinal bleeding was present; however, it never became massive and was satisfactorily controlled by the hourly instillation of antacids through a nasogastric tube.

Hypertension was noted a few days after admission to hospital. Systolic pressures as high as 180 mm of mercury were observed. Diastolic pressures ranged as high as 110 mm of mercury. The hypertension was poorly controlled by administration of a combination of hydralazine hydrochloride and propranolol hydrochloride. An intravenous pyelogram suggested better concentration of contrast in the right kidney than in the left. An abdominal aortogram showed normal renal arteries and kidneys as did the radiorenogram. Urine catecholamines were not elevated.

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Submitted March 17, 1980.

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**Figure 1.**—These two photographs show examples of the typical flower-like appearance of lightning burns.

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Administration of the antihypertensive drugs was continued and blood pressure was 112/80 mm of mercury at the time of discharge from the hospital.

The lightning burns on the thighs spontaneously healed, as did most of the areas on the right leg. This healing was complete within ten days. A few areas of full thickness burn were present on the right leg. Multiple operative procedures were required for the treatment of the full thickness burns on the chest, hands, neck and right leg. Split thickness skin grafting of these areas was done.

Intensive occupational, physical and speech therapy was given during the course of the hospital stay and more intensively before the child's discharge 2½ months following his injury. On visits to the office after discharge, the patient was found to have a total mental, physical and emotional recovery.

### Discussion

Victims of lightning stroke have disruption of many of their organ systems. The initial response to lightning stroke is paralysis of the vital centers, specifically the respiratory center, resulting in apnea, ventricular fibrillation or cardiac arrest. Artificial resuscitative measures should be begun promptly and continued until there is restoration of vital functions. In the case of our patient it was reported that mouth to mouth resuscitation was begun promptly by a neighbor, a physician, and continued by paramedical personnel at the scene. Upon arrival to a local hospital emergency department, the patient had resumed spontaneous respirations. He then vomited, aspirated and was intubated and placed on a volume ventilator. Numerous cases recounted in the literature give detailed reports of victims suffering respiratory, cardiac or cardiopulmonary arrest as a result of the lightning strike.<sup>2-6</sup> All references emphasized the importance of attempting resuscitation on all lightning stroke victims.<sup>2-6</sup> In fact, some authors have reported the cases of victims found and thought to be dead as a result of lightning stroke who were successfully resuscitated without significant residual damage although they had been without respirations for prolonged or unknown periods of time following injury.<sup>7,8</sup>

Cardiac arrhythmias are commonly seen following lightning injury.<sup>2,5-7</sup> ST segment elevation, T wave inversion and atrial and ventricular arrhythmias have been observed during the acute

phase of the injury.<sup>2,6,8,9</sup> Our patient's initial electrocardiogram showed ST segment elevation in leads V<sub>2</sub> and V<sub>3</sub> as well as sinus tachycardia. Subsequent electrocardiograms, within 24 hours after injury, showed resolution of the ST segment elevation. As with our patient, most electrocardiographic abnormalities revert to a normal pattern without myocardial injury. It has been noted that "although minor ECG changes are frequent in survivors of lightning injury, clinical evidence of myocardial damage is uncommon."<sup>6</sup> There have been reports of ventricular fibrillation occurring as a result of lightning injuries. In the past 16 years, there have been only eight cases of documented myocardial injury secondary to lightning.<sup>6</sup> Hypertension has been reported in several cases.<sup>8,9</sup> One author suggested that "transient hypertension and tachycardia are secondary to adrenal stimulation with excess catecholamine release."<sup>6</sup> Hypertension was observed in our patient several days after admission with systolic pressures as high as 180 and diastolic pressures as high as 110 mm of mercury. Administration of hydralazine hydrochloride and propranolol hydrochloride poorly controlled his hypertension which persisted throughout his hospital course. A careful search for the cause of our patient's hypertension was made. What was probably erroneously thought to be a subtle abnormality of the intravenous pyelogram raised the suspicion of a renal vascular cause. However, results of additional studies, which included angiography and renal vein sampling for renin, were all within normal limits. Likewise, urinary catecholamines were not found to be elevated. Even though there is mention in the literature of transient hypertension associated with lightning injury, our patient's hypertension may be related solely to the idiopathic hypertension found in children with thermal injuries rather than any particular relationship to the lightning injury in this case.<sup>10</sup> At discharge our patient's blood pressure was 112 to 120/80 mm of mercury and no further hypertension was noted in follow-up.

Consistent findings of coma, semiconsciousness, amnesia, restlessness, hysteria and keraunoparalysis have been described in the literature.<sup>2-5,7-9</sup> Our patient was reportedly unconscious at the scene but upon admission to our burn facility he was in a semicomatose, restless state, moving all extremities. His level of consciousness vacillated between coma and semicoma, and on the

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12th hospital day he was completely awake and out of coma. Seizure activity, another frequently reported response to lightning injury, was observed in our patient on the day of injury and again six days later. At that time, anticonvulsant drug therapy was initiated and no subsequent seizures were observed.

Gastrointestinal complications associated with lightning injuries are not unique but similar to those seen with any type of major trauma or burn injury. The most common problem is early gastro- atonia with gastric dilatation. If this is not recognized immediately, vomiting may result and thus there is the ever present threat of aspiration pneumonia. This avoidable complication occurred in our patient within one hour after injury. Another gastrointestinal problem seen in burn victims, as well as other victims of major trauma, is that of Curling ulcer. Our patient did not have life-threatening upper intestinal bleeding; however, he did have documented gastric bleeding which abated with the hourly administration of antacids through the indwelling nasogastric tube.

Lightning burns, keraunographic markings, spidery arborescent patterns and lightning prints are all terms frequently used to describe the appearance of burn to the skin from lightning. These burns are superficial and heal spontaneously without scarring. In fact, some reports document a disappearance of the keraunographic markings within hours or days following injury. Our patient was admitted with burns over 31 percent of his total body surface area. Burns on his right leg and both thighs were the classic lightning burns or keraunographic markings (Figure 1). Burns on the neck, face, head, chest and right hand were partial and full thickness thermal burns resulting from the lightning igniting the child's jacket. Contemporary burn management, including fluid

resuscitation, hydrotherapy and administration of silver sulfadiazine with dressings to the wounds, was implemented. The *lightning burns* were healed by the tenth day after injury. The remaining thermal burns were closed with split thickness autogenous skin grafts.

During the convalescent phase of his care, unsteady gait, problems with coordination while feeding himself and hesitant nasal speech were observed. The boy had intensive physical, occupational and speech therapy while in hospital and was discharged following resolution of these problems. No continuing problems have been observed in this case.

### Summary

Lightning injuries, although relatively uncommon, present problems which are not necessarily unique. We wish to stress that respiratory or cardiopulmonary arrest is the most immediate life-threatening complication. Cardiopulmonary resuscitation should be attempted on all lightning stroke victims, should be initiated promptly and should continue until there is a restoration of vital functions.

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